

Having thus defined the invention it is claimed:

1) In a chain drive having a rotatable chain wheel with pockets or teeth connected by straight lines to form a polygon for driving pivot chains or round link chains, the axis of said chain wheel rotatably fixed to a driven gear wheel of a spur gear driving arrangement, said driven gear wheel having a variably sized pitch circle for reducing variations in velocity and acceleration of said chain wheel, the improvement comprising:

said spur gear driving arrangement including a driving gear wheel for driving said driven gear wheel at an adjusted gear ratio, said chain wheel and said drive gear rotatable on a common axis; and

at least one of said driving and driven gear wheels having a noncircular toothed gear wheel configuration established relative to the pitch circle and including a plurality of rolling curve means for causing said chain wheel to have a minimum angular velocity at a corner of said polygon and a maximum velocity at a mid-point of a straight side of said polygon while said driving wheel rotates at a constant angular velocity.

2) The improvement of claim 1 wherein said polygon for said round link chains comprises a plurality of short straight lines and a plurality of long straight lines with a long straight line adjacent an end of a short straight line, said short straight lines corresponding to corners of said polygon, and the pitch circle radius of said noncircular gear wheel at the middle of any short straight line is greater than the pitch circle radius at the middle of any long straight line.

3) The improvement of claim 1 wherein said chain drive has pivot chains, said driven gear wheel having said noncircular toothed gear wheel configuration, said plurality of rolling curve means including a plurality of continuous rolling curve sections at the pitch curve circumference of said driven gear, said plurality of continuous rolling curve sections equal in number to the number of teeth in said chain wheel.

4) The improvement of claim 2 wherein said chain drive has round link chains, said driven gear wheel having said noncircular toothed gear wheel configuration,

said rolling curve means including a plurality of continuous rolling curve sections at the pitch curve circumference of said driven gear, said plurality of continuous rolling curve sections equal in number to twice the number of teeth in said chain wheel.

5) The improvement of claim 3 wherein said driving gear wheel has a noncircular toothed gear wheel configuration, said noncircular configuration including a plurality of continuous rolling curve sections at the pitch curve circumference of said driving gear.

6) The improvement of claim 4 wherein said driving gear wheel has a noncircular toothed gear wheel configuration, said noncircular configuration including a plurality of continuous rolling curve sections at the pitch curve circumference of said driving gear.

7) The improvement of claim 5 wherein said driving gear wheel has an arbitrary number of said continuous rolling curve sections equal to or greater than one.

8) The improvement of claim 6 wherein said driving gear wheel has an even number of said continuous rolling curve sections.

9) The improvement of claim 1 wherein both said driven and driving gear wheels have a noncircular toothed gear wheel configuration, said rolling curve means comprising a plurality of continuous rolling curve sections and the number of said continuous rolling curve sections for said driving gear wheel is set relative to a pitch angle of said driving gear wheel to establish a set gear ratio of said driving gear wheel to said driven gear wheel.

10) The improvement of claim 9 wherein the geometric shape of said continuous rolling curve sections is set to produce a constant driving angular velocity determined by multiplying the driven angular velocity of said driven gear wheel determined by the expression  $\omega_2 = \omega_1 / i$  with a gear ratio,  $i_m$ , established at the corner middle of said polygon and the cosine of the driven angle  $\varphi_2$ , to achieve said set gear reduction,  $i$ , according to the relation  $i = i_m \cos \varphi_2$  where:

$\omega_2$  is the angular velocity of said driven gear wheel,

$\omega_1$  is the angular velocity of said driving gear wheel,

$\varphi_2$  is the angle of rotation of said driven gear wheel.

5 11) The improvement of claim 10 wherein said continuous rolling curve sections have a geometric shape that allows said set gear ratio,  $i$ , to be approximated by mathematical techniques selected from the group consisting of basic polynomials, composite polynomials, trigonometric functions, Fourier series, periodic mathematical functions, approximating mathematical functions, and sections of  
10 eccentric circular arcs.

12) The improvement of claim 5 wherein a set gear ratio is established according to the relationship  $i_m = \varphi_1 / \sin \alpha_2$

where:

$i_m$  is the gear ratio at the corner middle of said polygon;

$\varphi_1$  is the angle of rotation of said driving gear wheel; and,

$\alpha_2$  is the pitch angle of said driven gear wheel.

13) The improvement of claim 6 wherein a set gear ratio is established according to the relationship

$$i_m = \frac{\beta_1 + \gamma_1}{\sin \beta_2 + \sin \gamma_2}$$

where:

$i_m$  is the gear ratio at the center of a short straight line of said polygon;

$\beta_1$  is the pitch angle of said driving gear wheel for said long polygon side;

$\beta_2$  is the pitch angle of said driven gear wheel for said long polygon side;

$\gamma_1$  is the pitch angle of said driving gear wheel for said short polygon side; and,

$\gamma_2$  is the pitch angle of said driven gear wheel for said short polygon side.

14) The improvement of claim 1 wherein both said driven and driving gear wheels have a noncircular toothed gear wheel configuration comprising a plurality of continuous rolling curve sections and the intersection of adjacent rolling curve

sections of said driven gear wheel have concave, unilaterally bent adjustment curve surfaces tangential to said rolling curve sections.

15) The improvement of claim 1 wherein both said driven and driving gear wheels have a noncircular toothed gear wheel configuration comprising a plurality of continuous rolling curve sections and the intersection of adjacent rolling curve sections of said driven gear is defined by an undulating adjustment curve surface in tangential contact at its ends to said rolling curve sections.

16) The improvement of claim 15 wherein said undulating curve is mathematically defined as being selected from the mathematical group consisting of a polynomial of fourth order and a modified trigonometric function of  $x \sin x$ .

17) The improvement of claim 14 wherein the radius of said undulating adjustment curve surface is equal to or greater than a cylindrical forming tool used to form said adjustment curve surface.

18) The improvement of claim 1 wherein both said driven and driving gear wheels have a noncircular toothed gear wheel configuration comprising a plurality of continuous rolling concave curve sections and said driven gear wheel comprises first and second part components nested into one another in an assembled condition, each part component having pie sections separated by an arcuate gap and each pie section having at its outer edge a continuous rolling section whereby said pie section of one part component nests into said arcuate gap of the other part component to form said driven gear wheel.

19) The improvement of claim 17 wherein said pie section for each part component extends radially inward to a centering hub section recessed relative to an end face of a part component, said hub section of one part component in face contact with said hub section of the other part component to form said assembled driven gear wheel.

20) The improvement of any one of claims 14 or 15 wherein the shape of said rolling curve sections adjacent the intersection of rolling curve sections is varied over

a portion of each rolling curve section adjacent said intersection to maintain said set gear ratio.

21) The improvement of any one of claims 3, 4, 9, 14 or 15 wherein said chain drive has a plurality of cascading driven and driving gear wheels so that the driven gear wheel of one driven and driving gear wheel set functions as the driving gear wheel of another driven and driving gear wheel set.

22) The improvement of claim 21 wherein at least one of said driven and driving gear sets that does not have its driven gear rotatively fixed to said chain wheel is a circular gear set.

23) The improvement of claim 21 wherein a plurality of driving and driven gear sets have noncircular rolling sections.

24) A spur gear chain drive arrangement for driving pivot chains or round link chains comprising:

a) a chain wheel having pockets or teeth for driving said chains forming a straight sided polygon having corners at said teeth and long straight sides between adjacent teeth when said chains are pivot chains and straight short side corners at said teeth and long side straight sides between adjacent teeth when said chains are round link chains;

b) a driving spur gear connected to a source of rotation;

c) a driven spur gear rotatably fixed and circumferentially positioned relative to said chain wheel on a common axis of rotation and rotatably driven by said driving gear;

d) said driving and driven gears having teeth formed on a plurality of concave, noncircular rolling sections extending about each gear's pitch circle circumference, each noncircular rolling section having a distance from the center of each gear which is longest at the center of said corners of said polygon and shortest at the center of said long straight sides of said polygon and said distances and the number of said rolling sections being set to produce a desired gear ratio between said driving and driven gears whereby for constant rotation of said driving gear,

angular velocities of said chain wheel varies as said driven gear rotates through a noncircular rolling section while velocities of said chains remain generally constant.

25) The chain drive arrangement of claim 24 wherein said chain drive has pivot chains and said plurality of continuous rolling curve sections in said driven gear being equal in number to the number of teeth in said chain wheel.

26) The chain drive arrangement of claim 24 wherein said chain drive has round chains and said plurality of continuous rolling curve sections of said driven gear are equal in number to twice the number of teeth in said chain wheel.

27) The chain drive arrangement of claims 25 or 26 wherein said driving gear has an arbitrary number of said continuous rolling curve sections equal to or greater than one.

28) The chain drive arrangement of claim 27 wherein for round link chains said driving gear wheel has an even number of said continuous rolling curve sections.

29) The chain drive arrangement of claim 27 wherein the number of said continuous rolling curve sections for said driving gear wheel is set relative to a pitch angle of said driving gear wheel to establish a set gear ratio of said driving gear wheel to said driven gear wheel.

30) The chain drive arrangement of claim 27 wherein for pivot chains, a set gear ratio is established according to the relationship  $i_m = \varphi_1 / \sin \alpha_2$

where:

$i_m$  is the gear ratio at the corner center of said polygon;

$\varphi_1$  is the angle of rotation of said driving gear wheel, and,

$\alpha_2$  is the pitch angle of said driven gear wheel.

31) The chain drive arrangement of claim 27 wherein for round link chains, a set gear ratio is established according to the relationship

$$i_m = \frac{\beta_1 + \gamma_1}{\sin \beta_2 + \sin \gamma_2}$$

where:

$i_m$  is the gear ratio at the corner centers of said polygon;

$\beta_1$  is the pitch angle of said driving gear wheel for said long polygon

side;

$\beta_2$  is the pitch angle of said driven gear wheel for said long polygon

side;

$\gamma_1$  is the pitch angle of said driving gear wheel for said short polygon

side; and,

$\gamma_2$  is the pitch angle of said driven gear wheel for said short polygon

side.

32) The chain drive arrangement of claim 27 wherein the intersection of adjacent rolling curve sections of said driven gear wheel have concave, unilaterally bent adjustment curve surfaces tangential to said rolling curve sections.

33) The chain drive arrangement of claim 27 wherein the intersection of adjacent rolling curve sections of said driven gear is defined by an undulating adjustment curve surface in tangential contact at its ends to said rolling curve sections.

34) The chain drive arrangement of claim 27 wherein said driven gear comprises first and second part components nested into one another in an assembled condition, each part component having pie sections separated by an arcuate gap and each pie section having at its outer edge a continuous rolling section whereby said pie section of one part component nests into said arcuate gap of the other part component to form said driven gear.

35) The chain drive arrangement of claim 34 wherein said pie section for each part component extends radially inward to a centering hub section recessed relative to an end face of a part component, said hub section of one part component in face contact with said hub section of the other part component to form said assembled driven gear wheel.

36) The chain drive arrangement of claim 27 wherein the configuration of said rolling curve section is in the shape of a cardioid and comprises that portion of a cardioid which most closely resembles a circular arc.

37) The chain drive arrangement of claim 36 wherein said rolling curve section of said driving gear is determined by the mathematical function of

$$r_1(\varphi_1) = \frac{a}{\sqrt{i_m^2 - \varphi_1^2} + 1}$$

where:

$r_1$  is locus of points defining the cardioid for the driving gear;

$a$  is distance between driving and driven gear centers;

$i_m$  is gear ratio at the middle of polygon corner;

$\varphi_1$  is angle of rolling curve arc of driving gear.

38) The chain drive of claim 36 wherein said rolling curve section of said driven gear is determined by the mathematical expression:

$$r_2 = \frac{a \cdot i_m \cos \varphi_2}{1 + i_m \cos \varphi_2}$$

where:

$r_2$  is locus of points defining the cardioid for the driven gear;

$a$  is the distance between centers of driving and driven gear;

$i_m$  is the gear ratio at the middle of a polygon corner; and,

$\varphi_2$  is the angle of rolling curve arc of driven gear.